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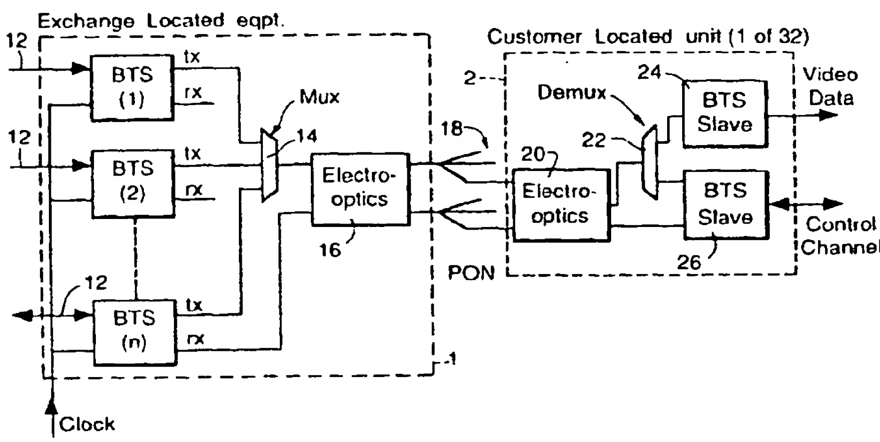

(57) Abstract

A communications system comprises a line terminal (1), a plurality of customer terminals (2), and a passive optical network for supporting traffic between the line terminal and the customer terminals. The line terminal (1) has a terminal unit means (BTS(n)) for relatively narrow bandwidth traffic, and a second terminal unit means (BTS(1) to BTS(n-1)) for relatively wider bandwidth traffic. A time domain multiplexer (14) is arranged to multiplex the traffic from the first and second terminal unit means for downstream transmission over the network (18). Each customer terminal (2) has a first service unit means for relatively narrow bandwidth traffic and a second service unit means for relatively wider bandwidth traffic. Each customer terminal (2) has a demultiplexer (22) arranged to receive multiplexed downstream traffic from the network (18), and to segregate the traffic between the first and second service unit means. Each customer terminal (2) has control means for generating relatively narrow bandwidth control signals for upstream transmission over the network, the second terminal unit means (BTS(1) to BTS(n-1)) of the line terminal (1) being responsive to the control signals from a given customer terminal (2) to control the transmission of the relatively wider bandwidth traffic to that customer terminal. The downstream transmission is by TDM and the upstream transmission is by TDMA.

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Passive Optical Network for Video on Demand

This invention relates to a communications system, and to a line terminal and a customer terminal therefor.

A known optical fibre communications network is the passive optical network (PON) which is used to support voice and data traffic - so-called telephony over a passive optical network (TPON). Managing the movement of traffic through a TPON involves a number of technical considerations.

TPON systems currently are designed to carry a range of voice/data services. At the time these were specified, it was assumed that any expansion of such systems to include video would be a long way into the future for regulatory reasons. The systems were, therefore, specified to allow the use of a second wavelength for broadband services on the PON at a later date, without impinging on existing systems.

The present applicant has developed a bit transport system (BTS) for use in a TPON. In this bit transport system, an optical line terminal (OLT) at an exchange transmits bit interleaved time division multiplex (TDM) frames downstream to all the receiving terminations on the network, known as optical network units (ONUs). The transmitted frames include both traffic data and control data. Each termination recognises, and responds to, appropriately-addressed portions of the data in the transmitted frames, and ignores the remainder of the frames.

In the upstream direction, each termination transmits data in a predetermined time slot, and the data from the different terminations are assembled at the OLT into time division multiple access (TDMA) frames of predetermined format.

One feature necessary to such a network is the provision of compensation for the differing delays associated with the different distances of the various terminations from the OLT. To this end, in the BTS system, each termination is arranged to transmit a ranging pulse timed to arrive in a predetermined portion of the upstream TDMA frame. The OLT is

arranged to monitor the timing and phase of the arrival of the ranging pulse from each of the terminations, and to return a servo-control signal to each termination to adjust the launch power of that termination, and to retard or advance its transmissions as appropriate. This active fine ranging enables the BTS to ensure the stability of the upstream TDMA frame and, for example, to compensate for fluctuations in timing due to such effects as changes in the operating temperature of the network. However, this places severe demands on the design of the OLT, requiring the measurement of the timing of received signals to within a fraction of a clock cycle in real-time.

Additionally, the BTS must respond to commands from the next level in the network management hierarchy to allocate traffic circuits and to handle the addition/deletion of subscribers and the change/reallocation of numbers (known as "churn"). In practice, BTS controllers have no intrinsic knowledge of the type of traffic to be transmitted from an exchange (or its format), or the bandwidth which should be allocated to a particular network customer termination; it is up to the network management hierarchy to provide the BTS with all the data necessary to enable it to map the appropriate number of traffic bits to a specified circuit.

Currently, the BTS is designed to be substantially symmetrical. Bandwidth configured in the downstream direction is also available in the upstream direction.

In summary, the BTS is a transport system which allows the bandwidth from an OLT to be distributed flexibly between a number of remote customer ONUs sharing a common point-to-multipoint passive split optical network. In current TPON systems, four BTS master units at the OLT are connected, via a time switch, to tributary units (TUs) which enables any 64k timeslot from any 2048 Kbit/s TU to be mapped to any timeslot on a particular BTS master unit. The BTS slave in the ONU distributes the TPON bandwidth to service units (SUs) which deliver the individual 64k timeslots to the customer for any given service.

The concept of video-on-demand (VoD) has recently been proposed. When using VoD, a subscriber to the service would be able to call up a video transmission from a library of titles as and when the subscriber wanted to, and to manipulate the video information, for example by freezing on a particular frame and fast searching backwards and forwards.

Now that video compression techniques have been developed, requiring 2Mbit/s or less per customer channel, the possibility of distributing video channels among customers is feasible, without the need for higher bandwidth transmission systems than are currently available.

The present invention provides a communications system comprising an OLT, a plurality of ONUs, and a PON for supporting traffic between the OLT and the ONUs, the OLT having a first terminal unit means for relatively narrow bandwidth traffic, a second terminal unit means for relatively wider bandwidth traffic, and a time domain multiplexer arranged to multiplex the traffic from the first and second terminal unit means for downstream transmission over the PON, each ONU having a first service unit means for relatively narrow bandwidth traffic, a second service unit means for relatively wider bandwidth traffic, a demultiplexer arranged to receive multiplexed downstream traffic from the PON and to segregate the traffic between the first and second service unit means, and control means for generating relatively narrow bandwidth control signals for upstream transmission over the PON, the second terminal unit means of the OLT being responsive to the control signals from a given ONU to control the transmission of the relatively wider bandwidth traffic to that ONU, wherein the downstream transmission is by TDM and the upstream transmission is by TDMA.

The invention is applicable to VoD for the wider bandwidth traffic. However, other wide bandwidth traffic can equally well be transmitted. In general, the system of the invention is suited to interactive information systems. For example, educational video, data and voice services can be

transmitted by a system according to the invention. While the information traffic in these systems is likely to be inherently unbalanced, the system of the invention can equally well be used to support wide bandwidth traffic of a substantially more balanced nature.

Advantageously, the first service unit means includes the control means.

In a preferred embodiment, the first terminal unit means is a BTS master unit, and the first service unit means is a corresponding BTS slave unit. In this case, the second terminal unit means may be constituted by a plurality of BTS master units, and the second service unit means is constituted by a BTS slave unit.

Alternatively, the second terminal unit means is constituted by a plurality of TUs, and the OLT further comprises a second time domain multiplexer operable to multiplex together the traffic from the TUs. Conveniently, the second service unit means of each ONU is constituted by a plurality of service units, and each ONU further comprises a second demultiplexer operable to demultiplex the segregated traffic for the service units of the second service unit means of that ONU.

In another preferred embodiment, the first terminal unit means is constituted by a plurality of BTS master units, a plurality of first TUs, and a time slot interchanger connecting the first TUs to the BTS master units. Advantageously, the second terminal unit means is constituted by a plurality of second TUs, a predetermined number of the second TUs being associated with each of the BTS master units. Preferably, a respective time domain multiplexer is operable to multiplex together the traffic from the TUs associated with each of the BTS master units. Each ONU may be provided with a BTS slave unit which is associated with first and second groups of service units constituting the first and second service unit means of that ONU. Conveniently, one of the service units of the first group of service units of each ONU includes the control means.

Preferably, the second terminal unit means of the OLT is arranged to provide video information such as VoD information.

The invention also provides an OLT for a communications system including a plurality of ONUs and a PON for supporting traffic between the OLT and the ONUs, the OLT comprising a first terminal unit means for relatively narrow bandwidth traffic, a second terminal unit means for relatively wider bandwidth traffic, a time domain multiplexer for multiplexing the traffic from the first and second terminal unit means for downstream TDM transmission, receiver means for receiving TDMA signals from the ONUs and for separating control signals transmitted by the ONUs from traffic transmitted by the ONus, and means for directing received control signals to the second terminal unit means thereby to control the transmission of the relatively wider bandwidth traffic to the ONUs.

The invention further provides an ONU for a communications system including an OLT, a plurality of other ONus, and a PON for supporting traffic between the OLT and the ONUs, the ONU comprising a first service unit means for relatively narrow bandwidth traffic, a second service unit means for relatively wider bandwidth traffic, a demultiplexer arranged to receive time domain multiplexed traffic, to demultiplex said traffic, and to segregate the traffic between the first and second service unit means, and control means associated with the first service unit means, the control means being operable to generate a relatively narrow bandwidth control signal for upstream TDMA transmission over the system to control the downstream transmission of the relatively wider bandwidth traffic.

The invention still further provides a method of operating a communications network comprising an OLT, a plurality of ONUs, and a PON for supporting traffic between the OLT and the ONUs, the method comprising the steps of time domain multiplexing, at the OLT, relatively narrow bandwidth traffic from a first terminal unit means and relatively wider

bandwidth traffic from a second terminal unit means, transmitting the multiplexed traffic downstream over the PON, segregating the relatively narrow and wider bandwidth traffic respectively between first and second service unit means at the ONUs and transmitting relatively narrow bandwidth control signals from the first service unit means upstream to the OLT from each of the ONUs, the second terminal unit means being responsive to the control signals to control the transmission of the relatively wider bandwidth traffic to the second service unit means, wherein the downstream transmission is by TDM and the upstream transmission is by TDMA.

The present invention can be put into practice in various ways, some of which will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a block diagram of a part of a TPON system;

Figure 2 is a diagram of an upstream BTS frame;

Figure 3 is a schematic block diagram of a first embodiment of the present invention;

Figures 4 (a) and (b) are diagrams respectively of a downstream BTS multiframe and basic frame;

Figures 5 (a) and (b) are diagrams of a downstream BTS superframe;

Figure 6 is a schematic block diagram of a BTS superframe decoder for use in the embodiment of Figure 3;

Figure 7 is a schematic block diagram of a second embodiment of the invention; and

Figure 8 is a schematic block diagram of a third embodiment of the invention.

Referring to the drawings, Figure 1 shows a TPON system comprising an OLT 1, a number of ONUs 2, and a PON 3 linking the OLT to the ONUs. Although, for clarity, only three ONUs 2 are shown, in practice many more will be connected to the OLT 1 via the PON 3. Typically, the OLT 1 is located in a local exchange, and the ONUs 2 are subscriber stations in domestic or commercial premises in the

neighbourhood of the local exchange.

Using a BTS, the OLT 1 transmits data over the PON 3 as TDM frames having a predetermined format. The frames include control channels addressed to specific ones of the ONUs 2 to control, amongst other parameters, the amplitude and timing of the optical signals transmitted onto the PON 3 by the ONUs.

In the upstream direction, each ONU 2 transmits data in a predetermined time slot, which data is assembled into a TDMA multiframe at the OLT 1. Since the TPON system is synchronous in operation, it is necessary to control the timing of the ONUs 2 both to compensate for the different delays associated with different positions of the ONUs on the PON 3, and to correct for any variation in the delay arising, for example, from local fluctuations in the temperature of the network.

Figure 2 shows the format of an upstream multiframe. Traffic data is transmitted to the OLT 1 in 80 basic frames BF0 to BF79. The basic frames BF0 to BF79 of the multiframe are preceded by a header H which includes a phase-2 ranging section R which is 720 bits long. Each ONU 2 is arranged to transmit onto the PON 3 a ranging pulse timed to arrive at a predetermined position within the ranging section R. The OLT 1 determines the phase of each arriving ranging pulse, and then transmits control signals to the respective ONU 2 to adjust the launch power of that ONU, and to retard or advance the timing of the transmission from that ONU in order to minimise the phase offset between the received data from that customer terminal and the intended position of that data within the return frame structure.

Referring to Figure 3, a simple implementation of the invention is shown for full duplex operation at 20.48Mbit/s with overlaid video data. The system comprises a bank of BTS master units BTS(1) to BTS(n) which are located in the OLT 1. Each BTS master unit BTS(1) to BTS(n) has an incoming line 12 carrying the signal to be transmitted over a PON 18 coming from eight data streams. There is also a clock input 13

synchronising the BTS master units BTS(1) to BTS(n) to a common source.

Each BTS master unit BTS(1) to BTS(n) has a transmitting output tx and a receiving input rx. In this embodiment, the BTS master unit BTS(n) is arranged to support relatively narrow bandwidth duplex voice and data traffic. The other BTS master units BTS(1) to BTS(n-1) are arranged to support relatively wider bandwidth asymmetric traffic, such as VoD channels. A narrow bandwidth duplex control channel, associated with the VoD channels, for customer control of the received video information, uses a small proportion (e.g. 8 Kbit/s) of the bandwidth provided by the BTS master unit BTS(n) supporting the narrow bandwidth duplex traffic.

The transmitting outputs tx of the BTS master units BTS(1) to BTS(n) are commonly fed to the inputs of a time division multiplexer 14 which is also located in the OLT 1. The multiplexed output signal is then converted into an optical wavelength signal in an electro-optics converter 16, in which a laser light source having an output wavelength of 1310nm is amplitude modulated with, for example, pulse code modulated (PCM) traffic signals for transmission across the PON 18. The electro-optics converter 16 is also arranged to convert optical wavelength traffic received from the PON 18 into electrical signals.

An ONU 2 (see Figure 3) according to the invention comprises an electro-optics converter 20 similar to the electro-optics converter 16 in the OLT 1. The output from the converter 20 is connected to the input to a demultiplexer 22 which distributes the multiplexed signals between two conventional BTS slave units 24 and 26. In this embodiment, the slave unit 24 is a VoD output, this slave unit having an associated customer video channel for relatively broadband video signals. The other BTS slave unit 26 is used for the narrower bandwidth control channel between the video source and the customer. Thus, the narrow bandwidth BTS master unit BTS(n) in the OLT 1 and the slave unit 26 in the ONU 2 communicate via the control channel. It will be appreciated,

by the skilled person, that a full network will combine many exchanges and numerous customers. Only one OLT 1 and one ONU 2 are shown in Figure 3 for the sake of clarity. Each ONU 2 requires a channel for transmitting and receiving control signals associated with the VoD information. This is described above in relation to the narrow bandwidth BTS slave unit 26. However, the same slave unit 26 may service more than one VoD channel for each customer, depending on its capacity.

The skilled person will also be aware that the video signal itself represents a one-way, or severely asymmetrical, flow of traffic from the OLT 1, downstream across the PON 18 and to the video channel at the customer end. Conversely, the control channel represents a two-way, generally symmetrical, flow of traffic between the OLT 1 and the ONU 2. The control channel is specific to a particular customer, and comprises a narrow band full duplex (e.g. 9.6 kbit/s asynchronous) link between the ONU 2 and the OLT 1 in a normal narrower bandwidth voice/data channel. Thus, the control channel data is more normally representative of the bandwidth of the voice/data present on a conventional TPON.

The BTS frame structure is designed to carry traffic arriving at eight 2.352Mbit/s PCM ports at a BTS master unit. In addition to traffic, bandwidth needs to be allocated for BTS control and ranging. For simplicity, the frame structures in both directions have similar formats but differ in functional detail, e.g. data in the downstream direction is scrambled to facilitate clock recovery at the remote terminations.

The aggregate system baud rate is 20.48MBaud, and the multiframe frequency is 100Hz, giving a multiframe period of 10ms. The conventional BTS is a symmetrical transmission system, with the upstream direction of transmission being more complex than the downstream direction. According to the invention, it is possible to extend this multiplex in a TPON system to provide additional bandwidth in the downstream direction without modifying in any way the more complex

upstream TDMA protocol.

Referring to Figures 4(a) and (b), the conventional BTS downstream multiframe repeats every 10 ms. It consists of one sync frame 34 and 30 basic frames BF0 to BF79. Each basic frame BF0 to BF79 contains the channel data from eight 125µs source frames 35 (provided by the associated data streams) and 144 housekeeping bits 38 (see Figure 4(b)). Each source frame contains 294 channel bits.

The 125µs source frames are rate adapted to interface with the BTS master units BTS(1) to BTS(n), each of which receives the 8 x 294 bits per 125µs source frame from its data streams at 2.56 Mbit/s (this includes some redundant bit space). The bit streams are bit interleaved and time compressed (to 20.48 Mbit/s) in the BTS master units BTS(1) to BTS(n). They are then multiplexed in the multiplexer 14 and transmitted over the PON 18. This multiplexing, by a convenient factor (e.g. 2, 4, 8 or more - depending upon the number of BTS master unit BTS(1) to BTS(n)), enables the handling of the increased traffic requirements caused by the presence of the video traffic.

At the customer end, the slave unit 24 is able to retrieve a minimum of one bit per basic frame of the multiframe. Thus, the minimum channel size available from a decompressed 125µs source frame at the customer end is 8 kbit/s.

The sync frame 34 of the multiframe is subdivided into two main areas: a 196 bit multiframe sync pattern 40 and a 4096 bit optical time domain reflectometry (OTDR) area 42. The OTDR area 42 is not always fully used, if at all, and is, therefore, used for alignment of a superframe for the system according to the invention.

Referring to Figure 5(a), the input to the multiplexer 14 is a superframe constituted by a sequence of multiframes from the BTS master units BTS(1) to BTS(n).

A superframe incorporating the wider bandwidth traffic of, for example the VoD service, is an enhanced version of the basic BTS downstream multiframe. The superframe can be

generated simply by interleaving the bits from the multiframes from the BTS master units BTS(1) to BTS(n). The multiframe from the BTS master unit BTS(n) contains a unique reference pattern in its OTDR area 42 which enables its location within the superframe to be determined at the ONU 2. From this datum position, the positions of the rest of the multiframes can be determined. The bit-interleaved multiframes, making up the superframe from the multiplexer, are shown in Figure 5(b).

Referring to Figure 6, at the ONU 2, the superframe demultiplexer 22 comprises a length-N shift register 64 which clocks in the superframe data serially at a line clock rate. A 1-of-N decoder 46 is connected to the parallel output of the shift register 44. An output from the shift register 44 is selected, using the 1-of-N decoder 46, according to the value of an input from a counter 48. A latch 50, clocked at the BTS multiframe bit rate, selects one of the multiframes of the BTS master units BTS(1) to BTS(n) in the superframe. The BTS multiframe bit clock rate is the superframe bit clock divided by N. The OTDR pattern in the selected multiframe is compared, by a pattern detector 52, with the unique reference pattern in the OTDR area 42 of the sync frame 34.

An "out of sync." pulse is generated if the pattern detector 52 fails to find the unique reference pattern after a number of multiframe periods. This unique reference pattern is present only in the OTDR area 42 of the multiframe from the BTS master unit BTS(n). If the pattern is not found, the counter 48 is incremented by the "out of sync." pulse. This process continues until the pattern detector 52 detects the correct pattern. The counter 48 will then remain stable, and the multiframe from the BTS master unit BTS(n) in the superframe at the input to a shift register 56 - this input coming from the 1-of-N decoder 56 - will be aligned with the BTS multiframe bit clock. The data 54 at the output of the latch 50 is the multiframe from the BTS master unit BTS(n) containing the narrow band traffic.

The shift register 56 delays the aligned superframe by

N bits, for input to a second 1-of-N decoder 58 which selects a delayed version of the aligned superframe depending upon a video channel selection address input 60. The delayed superframe is sampled at the multiframe bit clock rate by a latch 62 which selects a specific multiframe from one of the BTS master units BTS(1) to BTS(n-1). The selected multiframe is then transmitted to the video SUs.

In all cases, narrow bandwidth control channels can be provided over the existing BTS. For example, a single 64 kbit/s digital control channel would require no modifications to the existing BTS upstream arrangements. The BTS supports channels as low as 8 kbit/s, so there is scope for providing an asymmetric control signal service of, say, 2048 + 8 kbit/s in the downstream direction, with only 8 Kbit/s upstream.

At the ONU 2, the received superframed data is de-multiplexed as described above. The BTS 20.48MHz recovered data stream is fed to the BTS slave unit on the line 54 as if it came from a conventional electro-optics receiver. The remaining de-multiplexed video data is fed to the BTS slave unit 26 which sorts the video channels.

As an example, using a multiplex derived from the BTS data rate multiplied by 8 (that is to say where n=8), there would be sufficient capacity to transport a 140 Mbit/s multiplex in addition to the narrower bandwidth traffic carried by the BTS, i.e.:

	Rate (Mbit/s)		Source
	20.48		BTS narrow bandwidth traffic
	139.264		Wide bandwidth traffic
	4.096		Superframing and control

Total	163.84	=	20.48 x 8

While Figure 3 represents one embodiment, the particular utility of the present invention derives from its implementation as an overlay on an existing voice/data TPON to carry wider bandwidth video or other information.

Figure 7 illustrates such a TPON system overlay, in which a conventional voice/data system BTS master unit 70 receives and sends traffic in a conventional manner. The BTS

master unit 70 is connected to the PON 18 through an electro-optics converter and multiplexer module 72. Two or more multiplexed VoD channels are applied to a pair of TUs 74, and are then combined in a multiplexer 76. The BTS channels are multiplexed together with the multiplexed video channels in the multiplexer module 72. The output from the multiplexer module 72 is transmitted downstream over the PON 18.

At the ONU 2, an electro-optics converter and demultiplexer module 78 receives the broadcast optical signal, and converts this to an electrical signal containing the superframe of narrow band and broadband overlay components. This superframe, generated by the electro-optics converter and multiplexer module 72, comprises three components - the original narrow band traffic, the broadband video overlay traffic, and a superframe synchronisation pattern. This superframe is demultiplexed to give two output signals - the original narrow band signal, which is routed to a narrow band transport module (a BTS slave unit) 84, and the broadband overlay multiplex, which is routed to a video channel demultiplexer 80, and hence to customer SUs 82. As with the embodiment of Figure 3, the narrow band BTS slave unit 84 carries the control channel between the video source and the customer. The demultiplexer 80 is similar to the demultiplexer 22 described above with reference to Figure 6, and uses a similar technique for demultiplexing.

Thus, the provision of VoD across a typical PON using BTS management requires the system bandwidth to be increased to make room for the additional data. The optical fibre network is able to support the increased bandwidth. The additional housekeeping capacity is available within the 4096 spare OTDR bits in the multiframe. Control of the video data is conveniently governed over a single unmodified 8 kbit/s upstream channel on the BTS network itself.

This technique involves minimal changes to existing equipment designs. In practice, new electro-optics cards are used to replace the existing cards to provide the wider bandwidth optics necessary to access the BTS multiplexer. By

pre-multiplexing the video channels, and applying the multiplexed video data to the BTS multiplexer, the original multiplexer may be usable without upgrading, realising a further saving in line hardware modifications.

Recently, the maximum safe power output level for Class 3 lasers has been increased. There is more than enough scope to allow increased optical output to compensate for the lower noise margin which accompanies a wider bandwidth system for use with PONs.

While the invention is particularly attractive as a modification of an existing TPON system, the invention can be implemented as a dedicated network. An example is shown in Figure 8 which shows voice/data TUs 90 of a transmission system, each TU being connected to an associated BTS master unit 92 through a timeslot interchanger 94. Each BTS master unit 92 is associated with its own PON 18, so that each the PONs can be connected to each of the TUs 90. Each of the BTS master units 92 is associated with respective further TUs 96 which are associated with VoD channels. The TUs 96 of each BTS master unit 92 are multiplexed together by a respective multiplexer 98 and are applied to that BTS master unit along a secondary bus 100. Each BTS master unit 92 multiplexes the incoming VoD channel bits with those from the TUs 90 to create the superframe for conversion by an electro-optics converter 102, and subsequent distribution across the respective PON 18. Of course, the system would, in practice, comprise a plurality of BTS master units 92, whereas only two are shown in Figure 8. The BTS master units 92 may be arranged to carry wider bandwidth traffic, as shown, or conventional voice/data traffic.

At an ONU, the superframe is reconverted into an electrical signal in an electro-optic demodulator 104, and relayed to an appropriate BTS slave 106. The BTS slave 106 isolates the VoD channels, and demultiplexes then to be sent on to video customer SUs 108. The control signals for the VoD are, again, allocated an 8 kbit/s channel slot on the conventional upstream BTS managed network by means of one of

a plurality of narrow band service units 110.

CLAIMS

1. A communications system comprising an OLT, a plurality of ONUs, and a PON for supporting traffic between the OLT and the ONUs, the OLT having a first terminal unit means for relatively narrow bandwidth traffic, a second terminal unit means for relatively wider bandwidth traffic, and a time domain multiplexer arranged to multiplex the traffic from the first and second terminal unit means for downstream transmission over the PON, each ONU having a first service unit means for relatively narrow bandwidth traffic, a second service unit means for relatively wider bandwidth traffic, a demultiplexer arranged to receive multiplexed downstream traffic from the PON and to segregate the traffic between the first and second service unit means, and control means for generating relatively narrow bandwidth control signals for upstream transmission over the PON, the second terminal unit means of the OLT being responsive to the control signals from a given ONU to control the transmission of the relatively wider bandwidth traffic to that ONU, wherein the downstream transmission is by TDM and the upstream transmission is by TDMA.

2. A system as claimed in claim 1, in which the first service unit means includes the control means.

3. A system as claimed in claim 1 or claim 2, in which the first terminal unit means is a BTS master unit, and the first service unit means is a corresponding BTS slave unit.

4. A system as claimed in claim 3, in which the second terminal unit means is constituted by a plurality of BTS master units, and the second service unit means is constituted by a BTS slave unit.

5. A system as claimed in claim 3, in which the second terminal unit means is constituted by a plurality of TUs, and

the OLT further comprises a second time domain multiplexer operable to multiplex together the traffic from the TUs.

6. A system as claimed in claim 5, in which the second service unit means of each ONU is constituted by a plurality of service units, and each ONU further comprises a second demultiplexer operable to demultiplex the segregated traffic for the service units of the second service unit means of that ONU.

7. A system as claimed in claim 1 or claim 2, in which the first terminal unit means is constituted by a plurality of BTS master units, a plurality of first TUs, and a time slot interchanger connecting the first TUs to the BTS master units.

8. A system as claimed in claim 7, wherein the second terminal unit means is constituted by a plurality of second TUs, a predetermined number of the second TUs being associated with each of the BTS master units.

9. A system as claimed in claim 8, wherein a respective time domain multiplexer is operable to multiplex together the traffic from the TUs associated with each of the BTS master units.

10. A system as claimed in any one of claims 7 to 9, wherein each ONU is provided with a BTS slave unit which is associated with first and second groups of service units constituting the first and second service unit means of that ONU.

11. A system as claimed in claim 10, wherein one of the service units of the first group of service units of each ONU includes the control means.

12. A system as claimed in any one of claims 1 to 11,

wherein the second terminal unit means of the OLT is arranged to provide video information such as VoD information.

13. An OLT for a communications system including a plurality of ONUs and a PON for supporting traffic between the OLT and the ONUs, the OLT comprising a first terminal unit means for relatively narrow bandwidth traffic, a second terminal unit means for relatively wider bandwidth traffic, a time domain multiplexer for multiplexing the traffic from the first and second terminal unit means for downstream TDM transmission, receiver means for receiving TDMA signals from the ONUs and for separating control signals transmitted by the ONUs from traffic transmitted by the ONus, and means for directing received control signals to the second terminal unit means thereby to control the transmission of the relatively wider bandwidth traffic to the ONUs.

14. An OLT as claimed in claim 13, further comprising an electro-optics converter for converting downstream traffic for transmission at an optical wavelength.

15. An OLT as claimed in claim 13 or claim 14, in which the first terminal unit is a BTS master unit.

16. An OLT as claimed in claim 15, in which the second terminal unit means is constituted by a plurality of BTS master units.

17. An OLT as claimed in claim 15, in which the second terminal unit means is constituted by a plurality of TUs, and the OLT further comprises a second time domain multiplexer operable to multiplex together the traffic from the TUs.

18. An OLT as claimed in claim 13 or claim 14, in which the first terminal unit means is constituted by a plurality of BTS master units, a plurality of first TUs, and a time slot interchanger connecting the first TUs to the BTS master

units.

19. An OLT as claimed in claim 18, wherein the second terminal unit means is constituted by a plurality of second TUs, a predetermined number of the second TUs being associated with each of the BTS master units.

20. An OLT as claimed in claim 19, wherein a respective time domain multiplexer is operable to multiplex together the traffic from the TUs associated with each of the BTS master units.

21. An ONU for a communications system including an OLT, a plurality of other ONus, and a PON for supporting traffic between the OLT and the ONUs, the ONU comprising a first service unit means for relatively narrow bandwidth traffic, a second service unit means for relatively wider bandwidth traffic, a demultiplexer arranged to receive time domain multiplexed traffic, to demultiplex said traffic, and to segregate the traffic between the first and second service unit means, and control means associated with the first service unit means, the control means being operable to generate a relatively narrow bandwidth control signal for upstream TDMA transmission over the system to control the downstream transmission of the relatively wider bandwidth traffic.

22. An ONU as claimed in claim 21, in which the first service unit means is a BTS slave unit.

23. An ONU as claimed in claim 22, in which the second service unit means is a BTS slave unit.

24. An ONU as claimed in claim 22, in which the second service unit means is constituted by a plurality of service units, and in which the ONU further comprises a second demultiplexer operable to demultiplex the segregated traffic

for the service units of the second service unit means.

25. A system as claimed in claim 21, further comprising a BTS slave unit which is associated with first and second groups of service units constituting the first and second service unit means.

26. A system as claimed in claim 25, wherein one of the service units of the first group of service units includes the control means.

27. An ONU as claimed in any one of claims 21 to 26, further comprising an electro-optics converter for converting received multiplexed traffic at optical wavelengths into electrical signals for the first and second service unit means.

28. A method of operating a communications network comprising an OLT, a plurality of ONUs, and a PON for supporting traffic between the OLT and the ONUs, the method comprising the steps of time domain multiplexing, at the OLT, relatively narrow bandwidth traffic from a first terminal unit means and relatively wider bandwidth traffic from a second terminal unit means, transmitting the multiplexed traffic downstream over the PON, segregating the relatively narrow and wider bandwidth traffic respectively between first and second service unit means at the ONUs, and transmitting relatively narrow bandwidth control signals from the first service unit means upstream to the OLT from each of the ONUs, the second terminal unit means being responsive to the control signals to control the transmission of the relatively wider bandwidth traffic to the second service unit means, wherein the downstream transmission is by TDM and the upstream transmission is by TDMA.

29. A communications system comprising an OLT, a plurality of ONUs, and a PON for supporting traffic between the OLT and

the ONUs, the OLT having means for multiplexing narrow bandwidth traffic and wide bandwidth traffic for transmission downstream over the PON, each ONU having means for demultiplexing received multiplexed downstream traffic from the PON and for segregating the traffic into narrow bandwidth traffic and wide bandwidth traffic, each ONU having control means for generating narrow bandwidth control signals for upstream transmission over the PON, the OLT being responsive to the control signals from a given ONU to control the transmission of the wide bandwidth traffic to that ONU, wherein the downstream transmission is by TDM and the upstream transmission is by TDMA.

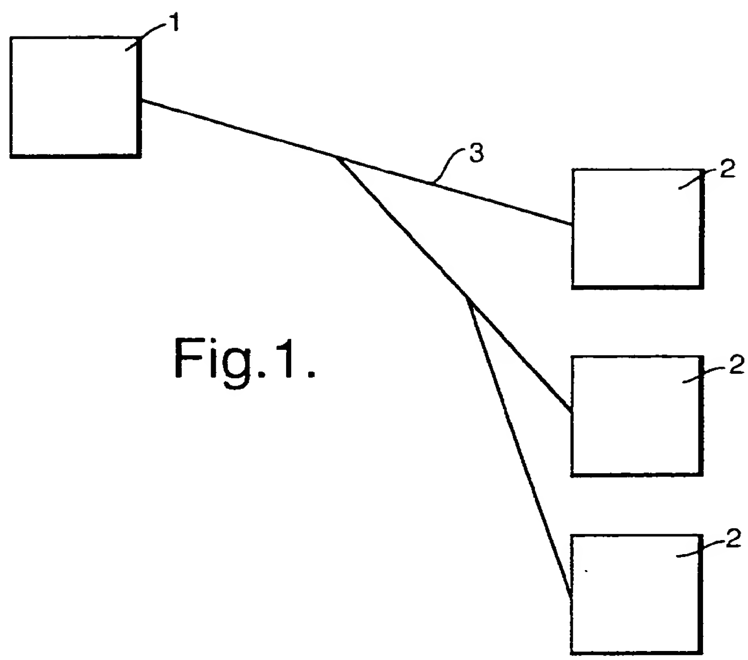
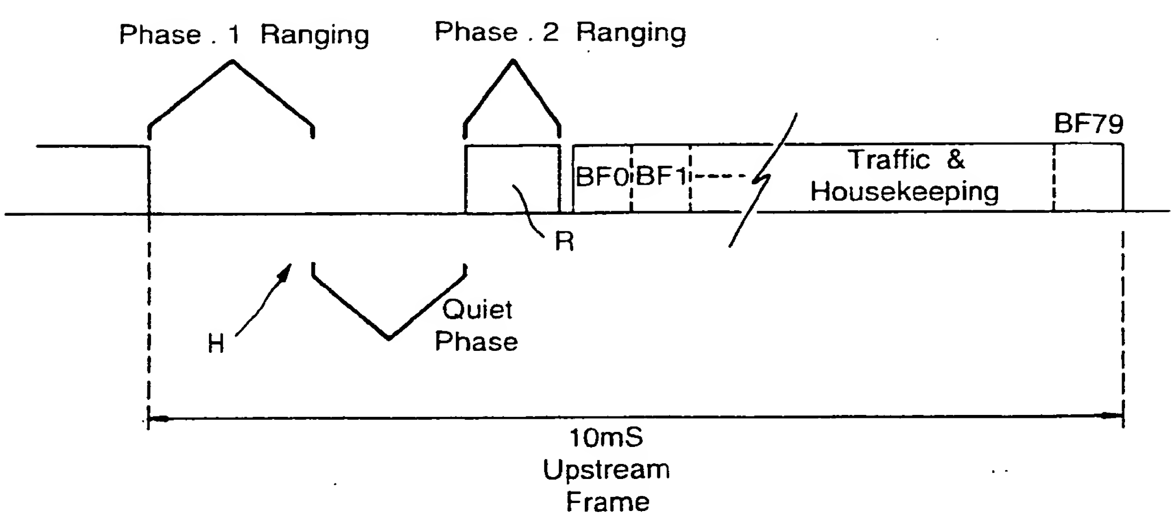


Fig.1.

Fig.2.



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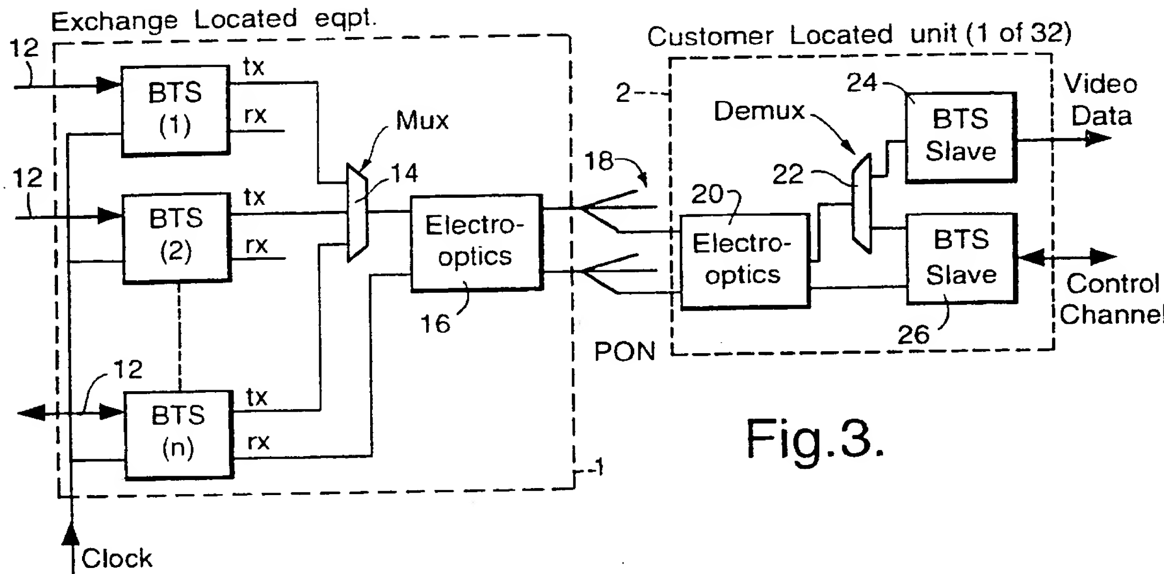
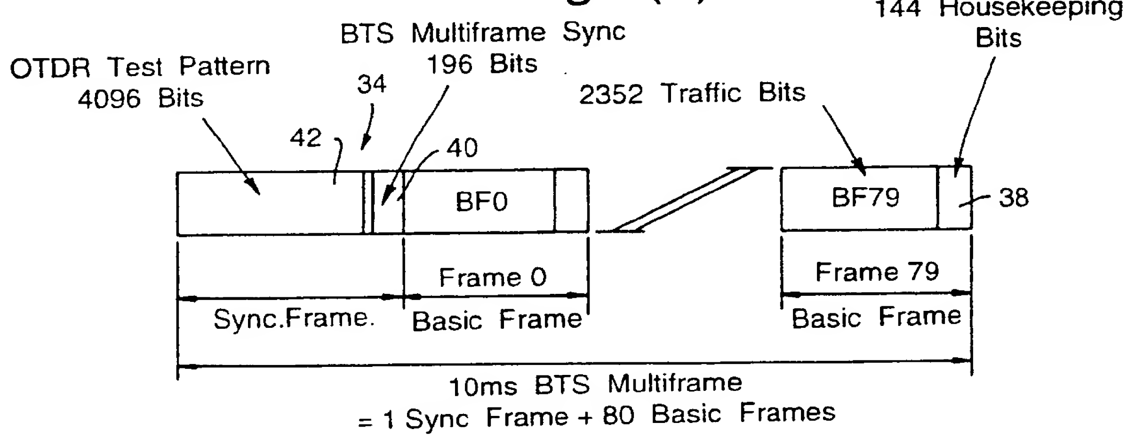


Fig.3.

Fig.4(a).



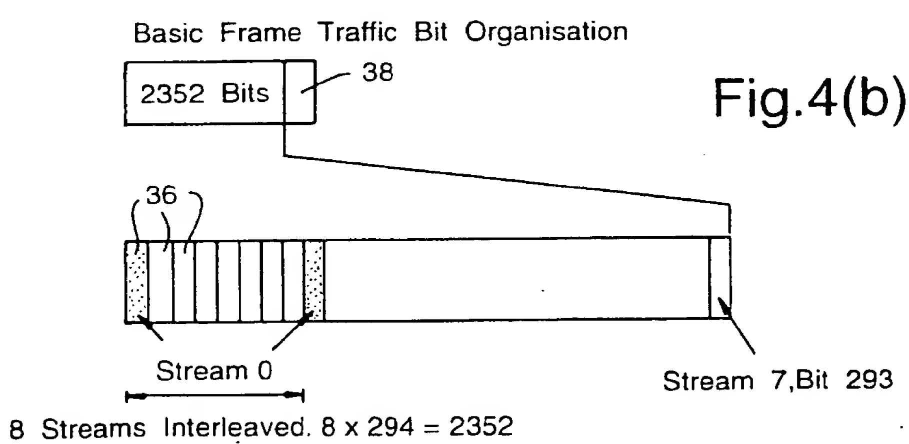
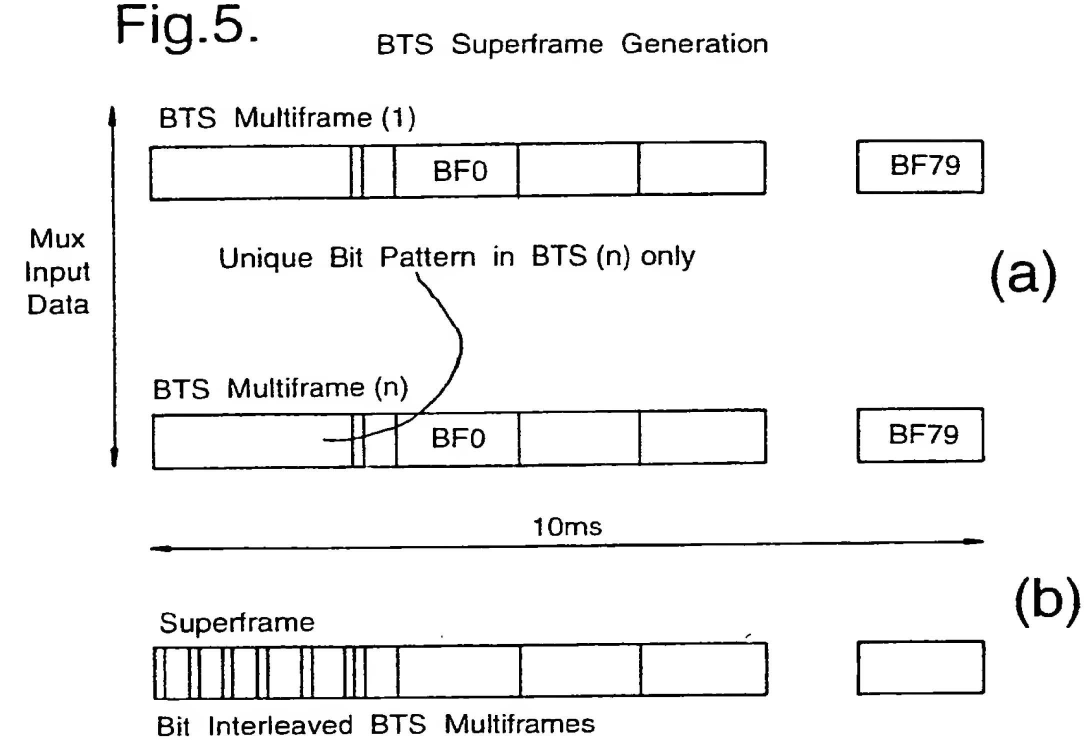


Fig.4(b).

Fig.5.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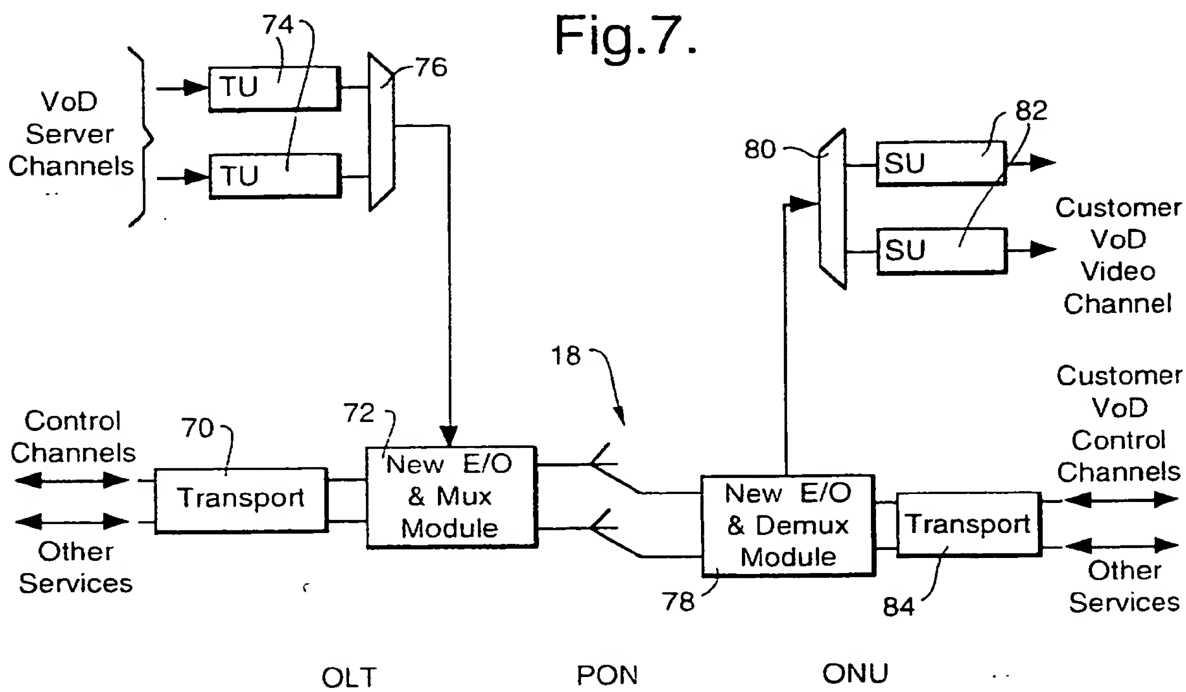
BF79
Mux Input Data
Unique Bit Pattern in BTS (n) only
(a)
BTS Multiframe (n)
BF0
BF79
10ms
(b)
Superframe
Bit Interleaved BTS Multiframes

Fig.7.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76
VoD Server Channels
TU
TU
82
80
SU
SU
Customer VoD Video Channel
18
Customer VoD Control Channels
Control Channels
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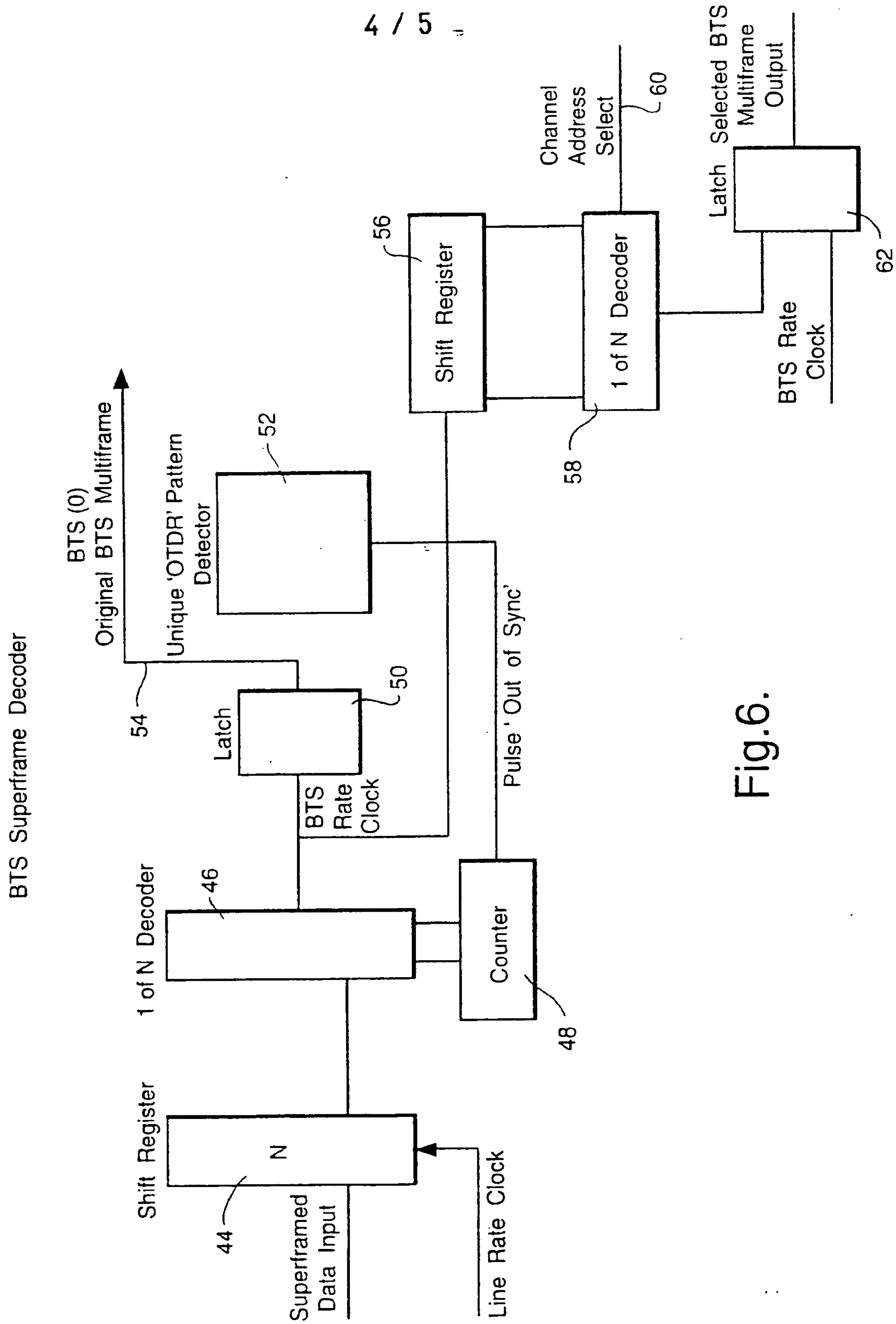
New E/O & Demux Module
Transport
Other Services
78
84
Other Services
OLT
PON
ONU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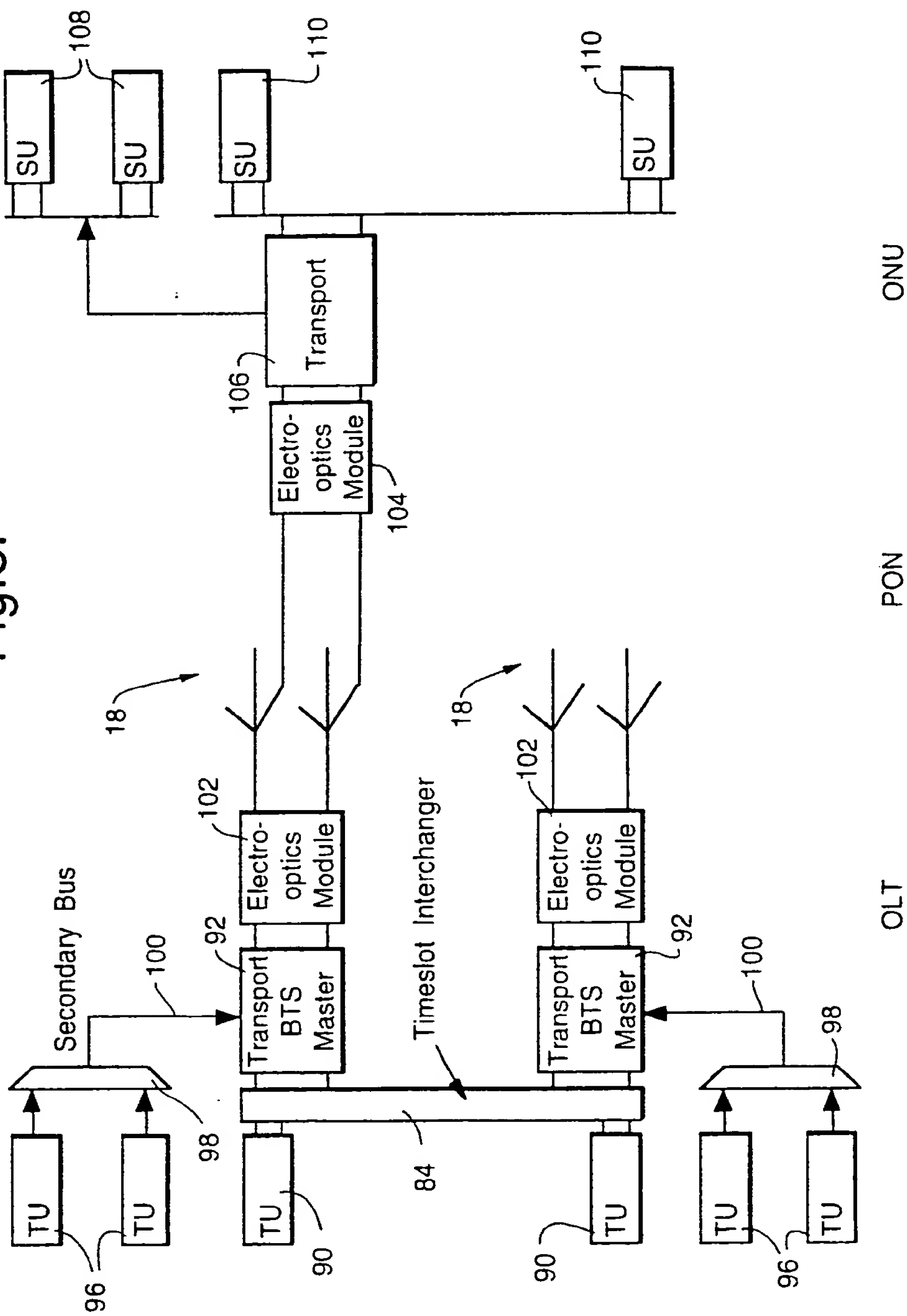
N
44
Superframed Data Input
Line Rate Clock
1 of N Decoder
46
Counter
48
Latch
50
BTS Rate Clock
54
Unique 'OTDR' Pattern Detector
52
BTS (0) Original BTS Multiframe
Pulse 'Out of Sync'
Shift Register
56
1 of N Decoder
58
Channel Address Select
60
Latch
62
Selected BTS Multiframe Output
BTS Rate Clock

Fig.6.

Fig.8.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Transport
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Electro-optics Module
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102
102
Electro-optics Module
Electro-optics Module
Transport BTS Master
Transport BTS Master
92
92
100
100
Secondary Bus
98
98
Timeslot Interchanger
84
TU
TU
TU
TU
TU
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96
96
90
90
ONU
PON
OLT

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 94/02744

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04J14/08 H04N7/22 H04N7/173

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04J H04B H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP,A,0 054 120 (LICENTIA) 23 June 1982 see page 3, line 11 - page 4, line 8 see page 6, line 32 - page 7, line 1; figures 1,2,4,5 ---	1-29
Y	42ND ANNUAL CONVENTION AND EXPOSITION OF THE NATIONAL CABLE TELEVISION ASSOCIATION, 6 June 1993, SAN FRANCISCO, US pages 368 - 375, XP410521 C.A. MERK ET AL. 'CATV Distribution in A Fiber-in-the Loop System Utilizing External Modulation' see abstract see page 368, right column, line 6 - line 18 see page 370, right column, line 33 - page 371, left column, line 12; figure 2 --- -/--	1-29

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 March 1995	25.04.95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Pieper, T

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Intern al Application No
PCT/GB 94/02744

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	GLOBECOM '91, vol.1, 2 December 1991, PHOENIX, US pages 597 - 601, XP326035 A.R.J. COOK ET AL. 'Broadband Digital Transmission Over Passive Optical Networks' see page 598, left column, line 16 - line 33 see page 598, right column, line 13 - line 19; figures 1-3 ---	1-29
A	WO,A,89 05077 (BRITISH TELECOMMUNICATIONS) 1 June 1989 see page 13, line 1 - line 21 see page 18, line 6 - line 16 see page 22, line 31 - page 23, line 8 see page 42, line 2 - line 17 see figures 1,7,13,14,23 ---	1-29
A	EP,A,0 425 871 (BRAODBAND TECHNOLOGIES) 8 May 1991 see column 4, line 54 - column 6, line 19 see column 6, line 52 - column 7, line 32 see column 8, line 30 - line 43 see column 9, line 12 - line 41 see column 10, line 30 - line 36 see figures 1-5 -----	1-3,7, 14,18, 21,27-29

1

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Information on patent family members

International Application No
PCT/GB 94/02744

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		EP-A,B	0318335	31-05-89
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Information on patent family members

International Application No
PCT/GB 94/02744

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